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MOBILE VESSEL ~~METHOD AND SYSTEM FOR IMPREGNATING~~ POROUS ARTICLES~~.~~

FIELD OF THE INVENTION

This invention relates to a system for impregnating porous articles with a curable sealant composition. More particularly, this invention relates to a system for impregnating porous articles which employs a mobile containment vessel wherein parts and sealant are transported within the vessel throughout an impregnation system.

BACKGROUND OF THE INVENTION

It is often desirable to form parts from lightweight metals in order to reduce the weight of a component or system and correspondingly reduce energy consumption as well as the costs of manufacture and maintenance thereof. With the advent of new machining technologies and emphasis on the environmental impact of power usage, more and more lightweight metals are being machined for more and more uses requiring these metals to perform multiple functions simultaneously. Examples of such metals include but are not limited to zinc, copper, brass, iron, aluminum, and various alloys.

An inherent problem with the use of lightweight metals is the presence of micropores which inhibit commercial viability. The occurrence of micropores is especially prevalent in components formed from metal powder. Porosity of porous parts is particularly problematic when such porous parts are utilized in fluid power systems or other liquid applications, where entrance of fluid in micropores can cause premature deterioration and fracture of the part. Other problems include the introduction of air and gas which may create processing or finishing difficulties as well as difficulties in the end use of the porous member.

In response to these problems, impregnation sealing technology emerged as a way to eliminate the micropores inherent in lightweight metal components yet retain the desirable performance characteristics thereof. During an impregnation sealing process, the porosity of porous articles is impregnated with a curable sealant composition, or "impregnant". Upon curing of the impregnant, the resulting sealed part is suitable for use in fluid exposure

applications, as well as facilitating plating, coating and further processing of formed articles. Thus, sealing of porosity is employed to render parts leak-proof in character and to prevent or minimize the incidence of internal corrosion in porous articles, particularly porous metal articles such as castings and sintered metal parts. This is necessary to make the article capable of withstanding liquid or gas pressure during use, and also to increase its density, improve its strength and frequently to prepare the surface of the article for a subsequent painting or plating operation.

The practice of using a liquid impregnant for the purpose of infallibly sealing the porosity of porous articles is a well-known and highly utilized process. A typical impregnation process is shown and described in U.S. Patent Nos. 3,672,942, 4,416,921 and 5,273,662, all of which are incorporated by reference herein. The impregnation of a given part is attained by degreasing and cleaning the part; subjecting the cleaned part to vacuum aspiration in a vacuum tank, thereby removing entrapped air from the minute pores in the part; immersing the part in a bath of an organic liquid impregnant such as an anaerobic impregnant; maintaining the part in a vacuum; and subsequently exposing the immersed part to atmospheric pressure, thereby causing the liquid impregnant to permeate the minute pores. In this case, the impregnation can be enhanced by supplying compressed air to the site of impregnation. Then, the liquid impregnant is returned to a storage reservoir and the part which has undergone the impregnation is centrifuged to expel any excess impregnant adhering to the surface thereof. Thereafter, the part may be cleaned with detergent to remove the liquid impregnant still remaining on the surface of the part. The impregnation treatment is completed by subjecting the impregnated part to a curing treatment.

Conventional impregnation processes are accomplished generally by three methods: wet vacuum impregnation, wet vacuum/pressure impregnation or dry vacuum/pressure impregnation. Among these impregnation methods, wet vacuum impregnation techniques are generally employed more frequently than the dry vacuum/pressure method described herein.

To effectively illustrate the prior art impregnation processes, examples of such processes are schematically depicted in the flow diagrams of Figures 1 and 2. The numbers

assigned to Figures 1 and 2 are indicative of the different operations or steps performed sequentially on a single containment vessel which is stationary.

During a conventional wet vacuum impregnation procedure as shown in Figure 1, porous parts are placed in a single container or basket at Block 10. The parts and the vessel are then inserted in an impregnation chamber at Block 12 where both parts and basket remain stationary for the duration of the impregnation process. At Block 14, the parts are submerged into a vacuum tank substantially filled with a flowable sealant composition. While the parts are in the vacuum tank, a short term vacuum cycle removes air from the porosity of the parts at Block 16. The duration of the vacuum cycle is dependent upon the material characteristics of the part being treated and the type of sealant used as an impregnant. The chamber is returned to ambient pressure so that sealant penetrates the evacuated porosity of the parts. At Block 18, the parts may then be spun briefly in the basket to eliminate excess sealant from the part surfaces and prevent subsequent curing of the impregnant thereon.

The prior art wet vacuum/pressure impregnation process, also shown in Figure 1, is similarly conducted, but with the impregnation chamber being pressurized at Block 17 at the end of the vacuum cycle at Block 16. Pressurization forces the sealant further into small porosity passages. The centrifuge step at Block 18 may then be carried out to remove and recover excess impregnant from the part surfaces and return the excess to a storage reservoir.

In the prior art dry vacuum/pressure impregnation method shown in Figure 2, the basket of porous articles which is inserted in a containment chamber at Block 20 is placed directly in a dry vacuum chamber at Block 22. At Block 24, air is evacuated from the porosity in the parts for a predetermined period of time which corresponds to the type of part being processed and the type of sealant used as an impregnant. At Block 26, a transfer valve is opened, allowing sealant to enter the chamber from a storage reservoir in fluid communication therewith. The chamber is automatically pressurized at Block 28 to force sealant into the parts. After impregnation, while the sealant is being returned to the storage reservoir, a centrifuge operation carried out at Block 30 spins the porous articles to remove and recover excess impregnant.

In existing porosity sealing impregnation systems, whether for wet or dry vacuum processing, processing vessels remain stationary relative to the porous parts and fluid impregnant, and the porous parts and fluid impregnant are transported therebetween. In other words, the vessel having porous parts therein remains in a single stationary position for the duration of the impregnation process. The main impregnation steps, i.e., vacuum, pressurization and centrifuging operations, all take place within this singular vessel. One disadvantage with this approach is that each of the main impregnation steps within the impregnation process is of lengthy duration. Moreover, these steps must be performed sequentially and therefore, under the prior art processes, it is necessary to wait for one step to be completed before the next step can begin. A single stationary vessel exacerbates the problem by ensuring a lengthy process - one vessel for all steps within the system translates into a lengthy production time and the proliferation of non-impregnated and partially-impregnated parts. The number of porous parts which are treated during a single cycle must therefore be calculated to match the overall needs of the production line. Consequently, this usually results in very large batch sizes, a situation which is contrary to modern day manufacturing methods which employ continuous throughput of small batches.

In addition, the use of a single large stationary vessel increases the magnitude of damage to the equipment in the event of a malfunction. Porosity sealing impregnation systems are very complex and expensive to build, maintain and operate. When liquid impregnant inadvertently cures within such equipment, the machines seize and malfunction and require expensive maintenance and repair. This also results in significant "lost production" since there was only one vessel in the manufacturing line and it is out of service.

Furthermore, if a problem occurs during one operation or step within the entire impregnation process, a large batch of parts can be ruined, reducing the number of porous articles that can be completed within the impregnation cycle and adding to the overall duration of an already extensive and time-consuming process. Such limitations not only lead to increased manufacturing costs due to lost time and materials, but also forestall further processing while troubleshooting procedures are executed to determine the source of manufacturing malfunctions.

Since the use of a single stationary processing vessel inhibits the efficient processing of porous articles in a manufacturing setting and promotes decimation of both machinery and parts, it is desirable to provide a system which overcomes these deficiencies.

SUMMARY OF THE INVENTION

The present invention provides a mobile vessel system for impregnating porous articles which uses a transportable vessel for each step in an impregnation process. By "transportable", it is meant that at least one, but desirably multiple vessels are sequentially transported from processing station to processing station. Thus, in a wet vacuum/pressure impregnation process, parts and impregnant are deposited into a containment vessel for application, then transported to a vacuum station. The vessel with the parts and impregnant therein is then transported to a pressure station for pressurization of the parts therein. Afterward, the vessel is transported to an impregnant return station for recovery of the excess sealant and deposit thereof into a storage reservoir. The vessel may be optionally transported to a centrifuge station for removal of excess sealant. As the independent vessel moves from station to station, similar vessels are simultaneously conveyed through the impregnation system in sequence.

One advantage of the present invention is the reduction in the size and complexity of impregnant and part handling systems. Such reduction is desirable because the implementation of fewer parts results in less maintenance and subsequent decreases in the cost of production.

Another advantage of the present invention is to provide the capability of processing a larger number of small batches of porous parts. This type of processing is desirable because it provides a more continuous flow of completed parts to better match the needs of the overall production line, decreases the number of non-impregnated and partially impregnated articles and reduces the likelihood of improperly processed batches.

Another advantage is less equipment damage. Should premature curing occur, it will only damage the vessel itself and not the entire system. This configuration reduces the

number of defective parts which result from an incorrectly performed procedure. Fewer parts, if any, are lost to "malmanufacture", while the remaining parts continue through the system to completion and commercial viability.

Another advantage of the present invention to increase the efficiency of an impregnation process by increasing the number of porous articles which can be simultaneously impregnated. Such a method includes implementing a mobile impregnation vessel having flowable impregnant and porous parts therein. Such a mobile vessel can be conveyed from processing station to processing station throughout an impregnation system, removing the limitations inherent in stationary processing vessels that are prevalent in existing impregnation systems. In a preferred embodiment of the present invention, this advantageous method is initiated by providing at least one mobile vessel and providing at least one porous article and an impregnating liquid therein. A series of stations is provided which define an impregnation sequence, wherein a specific impregnation step is performed on the porous articles. Example of such impregnation steps include but are not limited to application of a vacuum, pressurization or centrifuging. Each vessel is sequentially directed to at least one selected station chosen from the series of stations, where the corresponding specific impregnation step (or steps) is performed on the porous articles. Upon completion of an impregnation process, the impregnating liquid can be subsequently recovered for use once the vessel returns to its cue and repeats the process. In this manner, complete impregnation of a multitude of mobile vessels can be effected within a significantly decreased time frame relative to existing methods.

It is still another advantage of the present invention to accommodate a need for relatively long dwell times in particular stations versus those dwell times required in other stations. This can be achieved by increasing the vessel capacity of the specific station requiring prolonged dwell times.

Employment of this preferred method can be further optimized by inclusion of a separate de-aeration vessel which is independently operated when a dry vacuum process is utilized. A de-aeration step is carried out as a pre-treatment of the impregnating liquid prior

to use thereof in an impregnation process. During this step, the composition is transferred from a storage basin to a separate de-aeration vessel, and a vacuum is applied to the de-aeration vessel while the impregnating liquid is retained therein, thereby removing dissolved air from within said liquid prior to use on any porous parts. Upon completion of this de-aeration step, the liquid is subsequently transferred to a processing station for employment within an impregnation process cycle and any excess is easily transferred back to a storage basin from which such liquid was withdrawn.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a flow chart of a wet vacuum impregnation process and a wet vacuum/pressure impregnation process of the prior art.

Figure 2 shows a flow chart of a dry vacuum/pressure impregnation process of the prior art.

Figure 3 shows an elevational schematic representation of a mobile vessel impregnation system of the present invention.

Figure 4 shows a schematic representation of an independent degassing system used in a mobile vessel impregnation system of the present invention.

Figure 5 shows a schematic representation of vessel bank system used in a mobile vessel impregnation system of the present invention.

Figure 6 shows a schematic representation of a tip-and-pour impregnant return system used in a mobile vessel impregnation system of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the present invention, at least one transportable vessel is used to carry one or more porous parts through an impregnation process. The vessel travels from processing station to processing station such that each step of an impregnation process can be effected while the

flowable impregnant and porous parts remain within the vessel. In this manner, many small batches of parts can be produced in a smaller and less complex system, thereby reducing the cost of running and maintaining the system and further reducing the quantity of improperly produced parts in the event of a malfunction. The station's capacity to process vessels can also be adjusted to accommodate the required dwell time within the station.

Now referring to the figures, in which like elements are identically numbered, Figure 3 shows a schematic view of a mobile vessel impregnation system 30 of the present invention. System 30 executes a wet or dry vacuum/pressure impregnation process to a mobile impregnation vessel 31. Whether the process constitutes a wet or dry vacuum/pressure impregnation process is dependent upon when the liquid impregnant is added to the impregnation vessel (i.e. before or after application of a vacuum to the impregnation vessel). It is contemplated that the present invention can be applied to any type of impregnation process.

System 30 includes a storage tank 32, a de-aeration tank 34, a vacuum processing station 36, a pressurization processing station 38, an impregnant retrieval station 40 and a centrifuge processing station 42. However, reclamation of the impregnant can be made via piping or other forms of fluid communication with storage tank 32. Although all of the depicted elements are not essential to efficient operation of the system in accordance with the present invention, it is essential to have the basic elements for a wet vacuum, wet vacuum/pressure or dry vacuum/pressure process as described in the prior art.

A mobile vessel 31 is essential to the proper operation of the present invention. Mobile vessel 31 contains impregnant 33 and at least one porous article 2 therein. The capacity of vessel 31 is dependent upon the size and number of porous articles retained therein and the amount of liquid impregnant required to adequately impregnate the porosity of the articles. Vessel 31 is preferably diminutive in relation to conventional impregnation vessels so that vessel 31 is amenable to transport via hoist, forklift, conveyor or any other means conducive to the efficient attainment of proper impregnation of a plurality of porous parts.

Vessel 31 moves throughout system 30 sequentially through a series of processing stations which can include vacuum station 36, pressure station 38 and retrieval station 40. Each of processing stations 36, 38 and 40 is preferably a closed system responsible for completion of a specific operation or step within an impregnation process. As a vessel reaches a specific processing station, the step is carried out on the porous articles inside the mobile vessel. The vessel is subsequently transported to the next processing station within the impregnation process. For example, in a wet vacuum process, vessel 31 would travel with impregnant 33 and at least one porous article 2 therein to vacuum station 36. After the vacuum step has been completed, vessel 31 moves to retrieval station 40 for returning excess sealant to storage reservoir 32 and subsequently to centrifuging station 42 for removal of excess impregnant from the porous articles therein. The containment basket is removed from the vessel and may then convey the parts to a washing and an optional curing station (not shown) for acceleration of the curing function of the liquid impregnant upon the particular part. During the entire procedure through station 40, vessel 31 retains liquid impregnant 33 and any porous parts which are to be treated during an impregnation process.

The typical vacuum which is applied to vessel 31 at vacuum station 36 is 28 in Hg, which approaches an absolute vacuum. The typical pressure applied to vessel 31 at pressurization station 38 is maintained at 100 psi. These vacuum and pressure levels are considered to be sufficient to successfully impregnate a variety of porous articles and these levels define a widely used standard within the art. However, these levels can be adjusted accordingly in correspondence with the particular needs of the manufacturer without disturbing the integrity of the present invention.

As depicted in Figure 3, an impregnation process begins by drawing impregnant 33 from a storage tank 32 using a conventional pump or vacuum draw. Vessel 31 is transported to vacuum processing station 36 where the vessel is applied under a vacuum for a predetermined period of time. After the vacuum step has been completed, vessel 31 is conveyed to pressure processing station 38 where vessel 31 and the contents therein are subjected to a compressed air cycle to further force impregnant 33 into the porosity of the parts retained in vessel 31. Vessel 31 is then moved to impregnant retrieval station 40 where

any excess impregnant which remains therein returns to storage reservoir 32 to begin another impregnation cycle. Additionally, vessel 31 can be processed at centrifuging station 42, where parts are rapidly spun to remove excess impregnant, and once again the excess impregnant is returned to storage reservoir 32 via retrieval station 40.

Assuming impregnant 33 is an "anaerobic" sealant composition, impregnant 33 is continuously aerated or otherwise contained in an oxygenated environment in storage tank 32 (and vessel 31 if the dwell length demands it) to prevent premature polymerization thereof in situ. As used herein "anaerobic" refers to a substantial absence of oxygen. Assuming impregnant 33 is an "elevated temperature cure" sealant composition, impregnant 33 is continuously cooled as is required in storage tank 32 (and vessel 31 if the dwell length demands it) to prevent premature polymerization thereof in situ. Typically, the impregnant composition is maintained in a flowable state during the impregnation process to minimize the occurrence of premature curing or gelation on the impregnation machinery.

Impregnant 33 may be subject to a separate de-aeration pre-treatment which is completed in de-aeration tank 34 shown in Figure 3 prior to an impregnation cycle. This pre-treatment, illustrated further in Figure 4, is initiated at filling stage 1, wherein a vacuum is applied to de-aeration vessel 34 and a valve 70 opens de-aeration 34 to storage vessel 32, which is maintained at atmospheric pressure. As a result, impregnant 33 transfers from storage tank 32 to de-aeration tank 34. At degassing stage 2, valve 70 to storage tank 32 is closed and a vacuum is once again applied to de-aeration tank 34, thus removing any dissolved air from within impregnant 33. At transfer stage 3, a vacuum is applied to vessel 31 at vacuum station 36, and de-aeration tank 34 is opened to the atmosphere. Valve 74 opens de-aeration tank 34 to vessel 31, causing impregnant 33 to transfer to vessel 31. Finally, at return stage 4, valve 74 is closed and valves 70 and 72 are opened, causing excess impregnant in de-aeration tank 34 and in any associated piping to return to storage tank 34.

Because the de-aeration pre-treatment is performed in an independent vessel, there is no interference with the functions of either the storage vessel 32 and process vessel 31. In this manner, the occurrence of premature curing or gelation in the storage tank is also

minimized.

As vessel 31 is transported throughout system 30, subsequent impregnation vessels can sequentially proceed through the system, thereby simultaneously subjecting multiple vessels to a specific impregnation step. One desirable embodiment includes use of a vessel bank system. Such a system can maximize impregnation capacity. Such a bank system includes a series of stations, each having multiple positions for accommodating multiple vessels simultaneously. Desirably, the same impregnation step can be performed on multiple vessels simultaneously at each of the positions at a given station.

For example, movement of mobile vessel 31 within system 30 can be further optimized by a vessel bank system 50, shown in Figure 5. Vessel bank system 50 utilizes a plurality of mobile processing vessels, each of which are transported to a corresponding number of processing stations within a single impregnation system to create banks of processing stations where a particular stage or step of an impregnation process can be executed. Using the example shown in Figure 5, a plurality of pressure stations P is provided for simultaneously accommodating a corresponding number of mobile vessels which have singularly exited vacuum station V. Similarly, vessel bank system 50 can also include a plurality or bank of stations designed to perform each of the other steps of the impregnation process. In this manner, a plurality of vessels can simultaneously execute the same step in the impregnation process. The "number" of stations within a bank can then be calculated and deployed to suit the specific dwell time of that specific step. By using a bank of smaller, independent process vessels, the cost and complexity of a system can be significantly reduced without a reduction in production output.

In Figure 5, porous articles 2 are introduced into system 50 and loaded onto racks for delivery at arrival station A. The impregnation process is carried out as described previously, with a mobile vessel transporting liquid impregnant and porous articles therein from processing station to processing station. Vessel bank system 50 allows use of small, independent vessels, in which each vessel can be subject to processing one at a time or in groups, depending upon the step. Whereas, in the prior processes, a malfunction translated

into loss or restarting of an entire batch. With the present invention, if a single small batch is improperly produced, only that batch is lost.

Figure 5 also shows optional cooling stations 54. As depicted, the mobile vessels are placed in a pressure vessel at pressure station 38 which also has cooling capabilities within. The cooling is such that the temperature is maintained as required by the liquid impregnant. Cooling station 54 helps to prevent premature curing when the impregnant used within the system is a heat-curable or heat-cure accelerated composition.

In an impregnation system utilizing a vessel bank, the first step is moving a vessel containing parts 2 and impregnant 33 to a selected processing station. In the next step, a specific processing step, whether vacuum application, pressurization or centrifuging, is applied. The steps of selecting and/or directing a vessel to a given station and performing the specific operation or step assigned to a station on the porous articles in the vessel are reiterated for each vessel as each vessel moves from station to station until the sequence of required impregnation steps is completed. When the required dwell time for a given step has elapsed, the vessels are moved out to the next station. As shown by example in Figure 5, a vessel carrying an impregnant composition and porous articles therein is placed in a pressurized environment along with a plurality of similar vessels also awaiting lapse of the pressurization step dwell time.

This arrangement is especially desirable if the subject step durations differ from one another. The number of vessels which can be accommodated at one time is dependent on the size of the system and the dwell time required for completion of the subject step.

Any impregnant that did not absorb into the part has to be returned to the storage tank at impregnant retrieval station 40, shown in Figure 3. When impregnant 33 is returned to storage tank 32, at impregnant retrieval station 40 in Figure 3, return of the impregnant can alternatively be effected by an independent tip and pour impregnant return system 90 shown in Figure 6. Since it would be difficult and expensive for the mobile vessel 31 to have piping or valves due to its migratory nature, tip and pour system 90 aids the mobile vessel 31 in

returning excess impregnant for use later on and quickly returning the vessel to the manufacturing process for production of more parts with little interruption and maintenance.

Referring to Figure 6, impregnant 33 travels with mobile vessel 31 from processing station to processing station until it reaches retrieval station 40 (Step 1). At retrieval station 40, part 2 still is submerged in flowable impregnant 33. Impregnant 33 is poured out of vessel 31 into return funnel 92 (Step 2) such that vessel 31 is emptied (Step 3). After pouring excess impregnant out of the processing vessel, part 2 is subject to a centrifuging procedure at station 42 in which the part is rotated to remove excess impregnant from the exterior surface thereof (Step 4). Part 2 is then removed from vessel 31, leaving excess impregnant 33 therein (Step 5). The excess impregnant is poured out of vessel 31 into return funnel 92 (Step 6) so that no impregnant remains in the vessel and all excess has been returned to the storage vessel (Step 7). Centrifuging (Step 4) can also be enacted in independent and dedicated centrifuging container instead of in vessel 31. This dedicated container would funnel directly back to storage tank 32. Use of such a dedicated container would eliminate the need for a second tip and pour, and also return vessel 31 to service sooner.

The tip and pour impregnant return system provides increased flexibility in choices of centrifuging vessels, mobile vessels and vessels other than the primary impregnation vessels and allows for concurrent centrifuging and impregnation. Furthermore, like the independent degassing system described herein above, such a system further facilitates the processing of a large number of small batches, so that large numbers of parts are not subject to an improper and expensive impregnation process that yields a commercially useless product.

Impregnant 33 is chosen from a plurality of sealing compositions, depending upon the material composition of the part to be processed and the purpose of the sealant (i.e. fluid deterrence, plating, etc.). The curable composition may include any suitable sealant type such as phenolic resins, vinyl resins, silicone resins, acrylic resins, epoxy resins and the like. The present invention may also be implemented with resins curing by moisture exposure, actinic radiation (e.g. UV radiation) and ambient temperature curing. The choice of a suitable sealant is largely dictated by viscosity, temperature capabilities and the particular type of

porous part.

The present invention is particularly useful with (meth)acrylic resins. (Meth)acrylic resins have been almost exclusively used in porosity impregnation applications due to their highly advantageous viscosity characteristics and rapid curability in anaerobic cure and/or heat-cure formulations. Illustrative commercially available impregnation sealing compositions which may be utilized in the practice of the present invention include Resinol® 90C sealant (a registered trademark of Loctite Corporation, Hartford, CT), a heat-cured (meth)acrylic resin, and Resinol® RTC sealant (a registered trademark of Loctite Corporation, Hartford, CT), an anaerobic sealant composition curable at ambient temperatures in the substantial absence of oxygen.

Typical compositions include those which are curable via free-radical polymerization in the presence of suitable free-radical initiators, such as peroxy-type initiators. The (meth)acrylic monomers in heat-curable impregnant compositions may be curable through a heat-cure initiator being present therein, or an initiator system comprising an ingredient or combination of ingredients which at the desired elevated temperature conditions produce free radicals which promote polymerization. The (meth)acrylic monomer in an anaerobic cure porosity impregnant can likewise be associated with polymerization initiator constituents, which under certain conditions (i.e., the substantial absence of oxygen) promote polymerization. These initiators systems and associated accelerators are preferably present in the composition prior to use of the composition in the present invention. Such a composition that includes various initiators and initiator accelerators is disclosed in commonly assigned U.S. Patent No. 5,618,857, which is incorporated by reference herein.

As described hereinbefore, movement of vessel 31 in an impregnation system contemplated by the present invention can be effected by a directing means such as a hoist, forklift, motorization, rails or any other conveyance method or apparatus conducive to efficiently and properly executing the intendant impregnation process. In order to allow for the movement of the vessels, impregnant "delivery" lines are elevated above the vessel height, thereby eliminating intricate piping and valving structure which inhibit movement of

the vessels thereby. Proper placement and direction by any of these means among the impregnant delivery lines can be effected by executing machine logic via a programmable logic controller, PC-based controller or similar control apparatus.

Various changes to the foregoing described and shown methods and corresponding structures would now be evident to those skilled in the art. Accordingly, the particularly disclosed scope of the invention is set forth in the following claims.